Nonoperative Versus Operative Treatment for Displaced Finger Metacarpal Shaft Fractures

A Prospective, Noninferiority, Randomized Controlled Trial

Fredrik Peyronson, MD, Cecilia Stalberg Ostwald, MD, Nils P. Hailer, MD, Grey Giddins, FRCS(Orth), Torbjörn Vedung, MD, PhD, and Daniel Muder, MD, PhD

Investigation performed at the Department of Surgical Sciences/Orthopedics & Hand Surgery, Uppsala University Hospital, Uppsala, and the Department of Orthopedics, Falun Hospital, Falun, Sweden

Background: Finger metacarpal fractures represent up to 31% of all hand fractures, and most can be treated nonoperatively. Whether operative treatment is superior to nonoperative treatment for oblique and/or spiral finger metacarpal shaft fractures (MSFs) is unknown.

Methods: Forty-two patients with displaced oblique and/or spiral finger MSFs were randomized to either nonoperative treatment with unrestricted mobilization or operative treatment with screw fixation. The primary outcome was grip strength in the injured hand compared with the uninjured hand at the 1-year follow-up. Secondary outcomes were the Disabilities of the Arm, Shoulder and Hand score, range of motion, metacarpal shortening, complications, sick leave duration, patient satisfaction, and costs.

Results: All patients attended the 1-year follow-up. Mean grip strength relative to that in the contralateral hand was 104% (95% confidence interval [CI], 89% to 120%) in the nonoperative group and 96% (95% CI, 89% to 103%) in the operative group (p = 0.34). Mean metacarpal shortening was 5.3 mm (95% CI, 4.2 to 6.4 mm) in the nonoperative group and 2.3 mm (95% CI, 0.8 to 3.9 mm) in the operative group. In the nonoperative group, 1 minor complication was observed; in the operative group, there were 4 minor complications and 3 reoperations. The costs were estimated at 1,347 U.S. dollars (USD) for nonoperative treatment compared with 3,834 USD for operative treatment. Sick leave duration was significantly shorter in the nonoperative group (12 days [95% CI, 5 to 21 days] versus 35 days [95% CI, 20 to 54 days]) (p = 0.008).

Conclusions: When treated with unrestricted mobilization, patients with a single displaced spiral and/or oblique finger MSF have outcomes comparable to those treated operatively, despite metacarpal shortening. Costs are substantially higher (2.8 times) and sick leave is significantly higher in the operative group.

Level of Evidence: Therapeutic Level II. See Instructions for Authors for a complete description of levels of evidence.

Hand fractures represent 19% of all fractures; up to 31% of these are fractures of the finger metacarpals[1]. In general, metacarpal shaft fractures (MSFs) can be described as transverse, spiral and/or oblique, or comminuted. Most patients are of working age; therefore, MSFs result in high societal costs due to reduced ability to work during treatment and recovery[2]. However, the exact costs are unknown for these injuries[3].

Treatment of finger MSFs can be nonoperative, including early mobilization or closed reduction and immobilization. Operative options for different patterns of finger MSFs include Kirschner wire stabilization, open reduction and interfragmentary compression screws, or fixation with screws and a plate. Early mobilization with or without a supporting splint seems to give comparable results[4,5], as do immobilization in a cast[6,7] and operative treatment with open reduction and internal fixation[4,8,9]. According to the Swedish Fracture Register, 20% of approximately 7,000 spiral and/or oblique finger MSFs that were registered from 2011 to 2021 were treated operatively[10] (see Supplementary Appendix A). Surgery is

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJS/H303).

A **data-sharing statement** is provided with the online version of the article (http://links.lww.com/JBJS/H305).

often advised because of concerns about shortening of the metacarpals, leading to weakness and tendon imbalance[11-13], or rotational deformity, leading to scissoring (overlapping) of the injured finger in flexion. Complication rates after surgery with plates and screws range between 32% and 36%, with stiffness and malunion representing the 2 most common problems[14]. Complications after treatment with interfragmentary compression screws seem to be less common, with stiffness being the most frequently reported problem (57%)[15]. In 2015, Khan and Giddins described a prospective study of nonoperative treatment with early mobilization in patients with spiral/oblique finger MSFs, indicating good outcomes in terms of grip strength and range of motion when shortening is accepted as a means of fracture stabilization[5].

There is inadequate evidence to indicate whether operative or nonoperative treatment is better for treating finger MSFs[2,3]. Because of the lack of randomized controlled trials (RCTs) evaluating this fracture type, we conducted this noninferiority study of spiral and/or oblique displaced finger MSFs with or without rotational deformity; we compared nonoperative treatment with unrestricted mobilization to operative treatment with interfragmentary compression screws. All 4 non-thumb metacarpals were included because of their anatomic similarity, with the deep transverse metacarpal ligaments connecting the distal ends and limiting the amount of shortening.

We hypothesized that nonoperative treatment would yield clinical outcomes that are noninferior to those of operative treatment.

Materials and Methods

This study was approved by the Ethical Review Board at Uppsala University (Dnr. 2016/575, dated February 14, 2017; Dnr. 2016/575/1, dated April 18, 2018; Dnr. 2021-006709, dated March 7, 2021; and Dnr. 2021-07035-02, dated January 17, 2022). All of the patients agreed to participate and gave their informed consent. The study followed the Declaration of Helsinki. Registration at clinicaltrials.gov (NCT03067454) was completed before recruitment to the study was initiated.

Trial Design and Participants

This study was a prospective RCT with 2 equally sized parallel groups. Patient recruitment proceeded at Uppsala University Hospital from March 1, 2017, to May 6, 2020, and at the regional hospital of Falun in Sweden from March 1, 2019, to May 6, 2020. Among the 539 patients who were assessed for eligibility, 45 were randomized with respect to treatment. The baseline characteristics of the patients are shown in Table I. The most common reason for exclusion was insufficient fracture dislocation. See Figure 1 for a detailed CONSORT (Consolidated Standards of Reporting Trials) flowchart; inclusion and exclusion criteria are provided in Table II.

Randomization, Allocation Concealment, and Blinding

An independent statistical provider from the Uppsala Clinical Research Center at Uppsala University created a randomization

TABLE I Baseline Patient Characteristics

	Nonoperative (N = 22)	Operative (N = 20)
Mean age (range) *(yr)*	49 (18 to 83)	40 (23 to 69)
Female sex *(no. [%])*	12 (55)	5 (25)
Mean days from injury to randomization (range)	4.7 (1-9)	3.7 (1-10)
Injury to the dominant hand *(no. [%])*	8 (36)	12 (60)
Fractured metacarpal		
Second (n = 1)	1	0
Third (n = 6)	3	3
Fourth (n = 20)	10	10
Fifth (n = 15)	8	7
Rotational deformity at inclusion	10 (1 missing value)	2 (1 missing value)
Mean radiographic shortening at inclusion (range) *(mm)*	4.8 (1.5-8.0); (3 missing values)	4.8 (2.0-8.5); (1 missing value)
Traumatic injury from falling	9	6
Sports injury	5	10
Smoker		
Active smoker	1; 3 missing values	2; 1 missing value
Previous smoker	2	2
Occupation type		
Manual labor	5	11
Not manual labor or a student	11	8
Retired	6	1
Normal hand function before inclusion	22	20

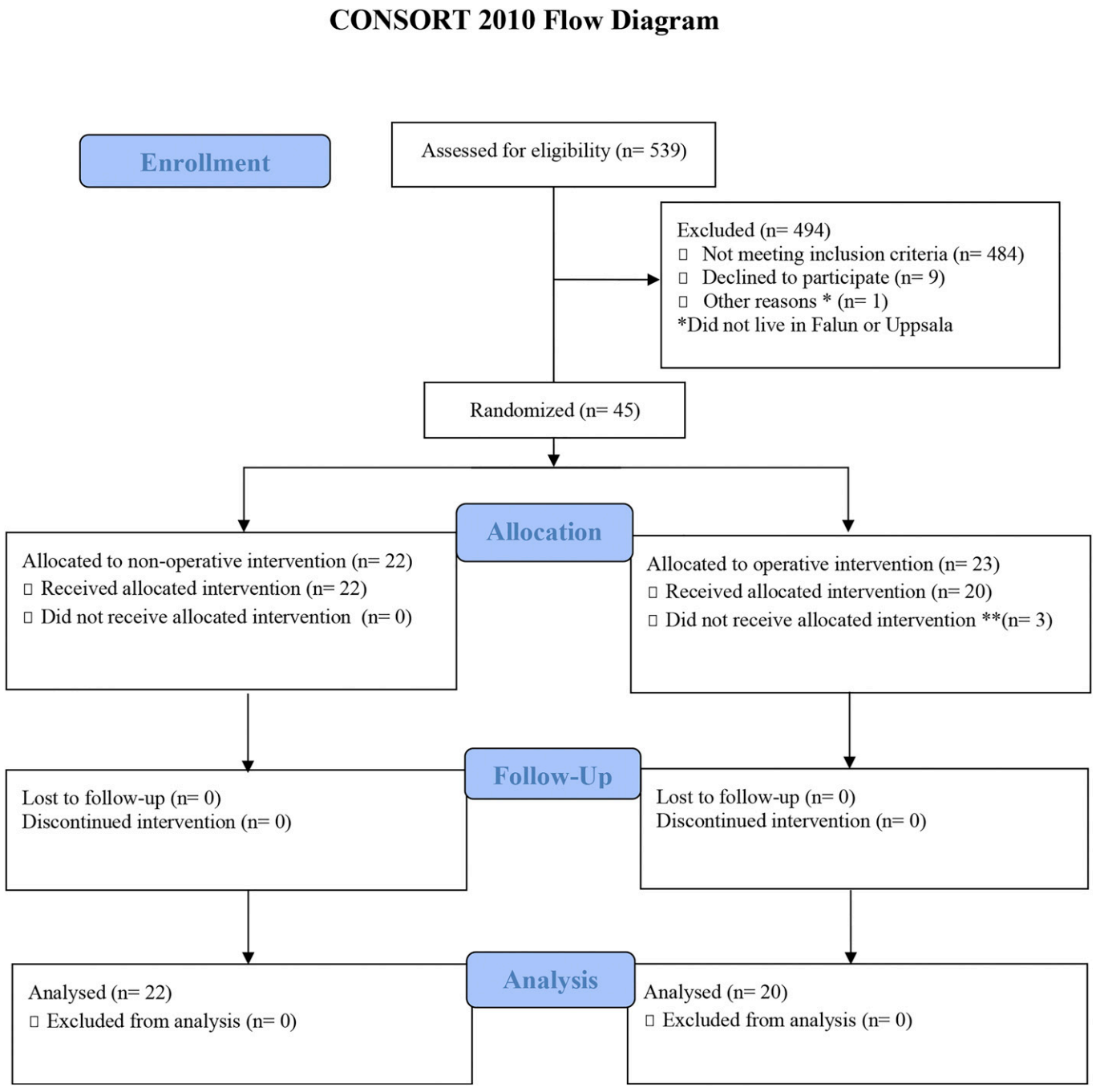

Fig. 1

Enrollment, randomization, treatment, and 1-year follow-up. **One patient had fracture comminution that was discovered during surgery; the comminution was fixed with Kirschner wires and the patient was excluded. One patient was excluded due to concomitant closed tendon rupture that had not been seen at inclusion. One patient was excluded due to a severe skin condition (infected eczema) at the planned site of incision (surgery was deemed contraindicated by the treating physician).

list with a 1:1 allocation ratio, in blocks of 4 or 6 in unknown order. Recruitment was conducted by the treating physicians and discontinued after 42 patients were enrolled and treated. All of the envelopes were sealed and only opened after patients had signed the informed consent form. The treating physicians, the physiotherapists, the occupational therapists, and the patients were not blinded to the treatment group after the envelopes had been opened.

Interventions

Nonoperative Group

Patients in the nonoperative group were mobilized immediately, allowing unrestricted use of the injured hand. Patients were initially assisted by a physiotherapist (Uppsala) or an occupational therapist (Falun), who introduced them to an early mobilization regimen and offered an optional resting splint that could be used

TABLE II Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
• Diaphyseal, single spiral, and oblique fractures of the index to little finger metacarpals • Fracture line length at least twice the diameter of the bone at the level of the fracture • At least 2-mm displacement and/or shortening of the fracture or malrotation • Normal hand function before the injury • Fracture <10 days old	• Multiple metacarpal fractures • Open fractures • Inability to follow instructions • Fracture line length less than twice the diameter of the bone at the level of the fracture • Abnormal hand function before the injury • Previous ipsilateral hand fractures • Fracture ≥10 days old at possible randomization

between training sessions or buddy taping if the patient sought comfort (see Supplementary Appendix B).

Operative Group

Using a standard longitudinal dorsal approach, fractures were reduced and stabilized with ≥2 interfragmentary compression screws (2 mm) or a dorsally placed variable-angle locking compression plate (VA-LCP) and screws (LCP Compact Hand 2.0; DePuy Synthes) (see Supplementary Appendix C). The level of experience of the operating surgeon was recorded along with the duration of the operation from start to finish.

Outcomes

Patients in the nonoperative and operative groups were assessed clinically at 1 week, 6 weeks, 3 months, and 1 year after recruitment. Patients in the operative group had an additional follow-up at 2 weeks after recruitment to remove the plaster cast that had been applied following surgery and to start mobilization in the same way as the nonoperative group. A goniometer was used to measure range of motion and extension lag in all of the finger joints. Total active motion (TAM) was calculated as a percentage of the uninjured hand. Rotational deformity was assessed by measuring the degree of scissoring of the injured finger over the adjacent finger. Complications, defined as events deviating from the expected recovery, were recorded. Posteroanterior and lateral radiographs were made at 1 and 6 weeks (Fig. 2). Grip strength was measured with a dynamometer (Jamar; Patterson Medical) at position II[16], and the mean of 3 consecutive measurements was calculated. Grip strength of the injured hand was calculated as a percentage of the strength of the contralateral hand at 1 year after recruitment and defined as the primary outcome measure (observer not blinded).

Patient-reported outcomes were assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) score[17], pain under load on a numeric rating scale (NRS) from 1 to 10 (1 being the lowest)[18], and cosmetic results and patient satisfaction with hand function on NRS scales from 1 to 10 (1 being the best) at inclusion and at 3 months and 1 year. We recorded whether hand function had been normal before the index injury and whether the patients were active smokers.

Shortening was measured on posteroanterior radiographs at inclusion, 1 week, and 6 weeks in 2 ways, recording the highest value in millimeters: (1) shortening was estimated using the metacarpal line when metacarpals II, IV, or V were affected, and (2) shortening was measured by identifying overlapping bone and distinct landmarks at the fracture site. The protocol that was used for radiographic measurement is provided in Supplementary Appendix D.

Treatment Costs and Sick Leave

Economic costs for nonoperative and operative treatment were calculated from the hospital databases and administration; total costs were provided for emergency department visits, radiographs, surgery, and postoperative care, including hospital stay and follow-up. The cost estimates did not reflect the actual treatment costs in this study; the cost estimates were based on standard treatment protocols for either nonoperative or operative treatment based on our clinical routine. The self-reported sick leave duration was recorded for each patient.

Sample Size Calculation

The noninferiority margin (NIM) was defined as a grip strength decrease of 15%, based on expected normal variations in grip strength between hands and between measurements. By using the same logic, a successful treatment outcome was defined as grip strength that was >85% of that in the uninjured hand[19]. Sample sizes were calculated with the assumption that 97% of patients in each group would achieve a successful outcome. For a 1-sided confidence interval (CI) of 97.5% and a power of 80%, each treatment group needed 21 patients.

Statistical Analysis

Continuous data were described as means with ranges and compared using the Student t test (for normally distributed data) and the Mann-Whitney U test (for non-normally distributed data). Estimation uncertainty was approximated by 2-sided 95% CIs. Categorical data were summarized in cross tables, and the Fisher exact test was used to assess the differences between the groups. P values of <0.05 were considered significant. Noninferiority was assessed by comparing the NIM with calculated CIs for continuous grip strength values. A sensitivity analysis of the effect of hand dominance on grip strength was performed, including grip strength and a variable indicating whether the dominant hand was injured plus an

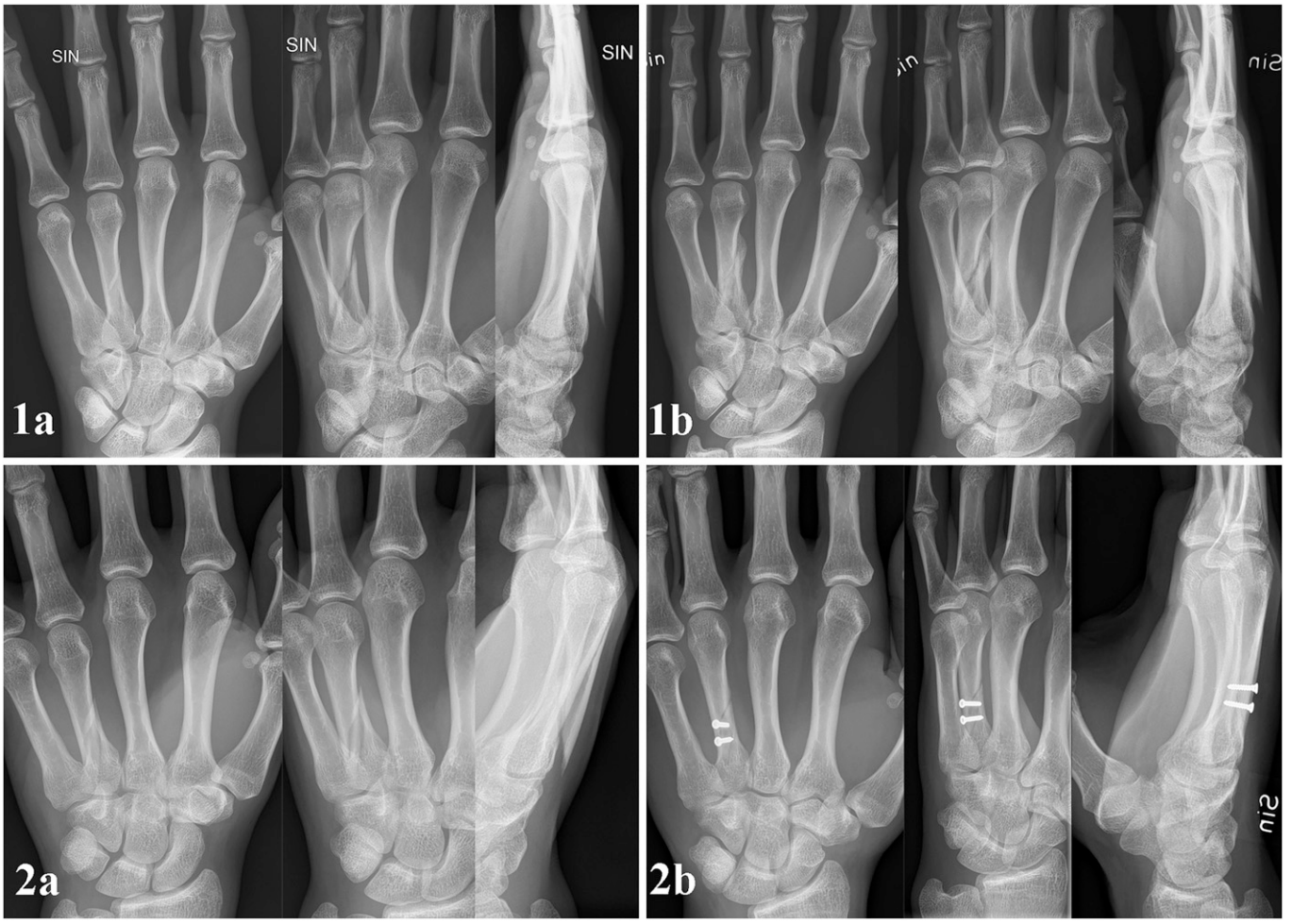

Fig. 2

Radiographs at inclusion (1a and 2a) and at the 6-week follow-up (1b and 2b). Projections included left to right, frontal, oblique, and sagittal views. The top row includes radiographs of a patient in the nonoperative group, and the bottom row includes radiographs of a patient from the operative group.

interaction term indicating whether the dominant hand was injured. Measurements of grip strength did not deviate substantially from a normal distribution, as visualized by histograms and quantile-quantile plots. The assumption of homoscedasticity was also not violated, as investigated by the Levene and Breusch-Pagan tests. Therefore, multiple linear regression was used for this analysis. All of the data were analyzed using RStudio (version 1.4.1717; R Foundation for Statistical Computing).

Source of Funding

There was no external funding source for this study.

Results

Characteristics of the Study Population

Between March 1, 2017, and May 6, 2020, 22 patients were assigned to nonoperative treatment and 20 patients were assigned to operative treatment. The proportions of injury to the dominant hand (nonoperative group, 8; operative group, 12; p = 0.22) and of the presence of any degree of rotational deformity at randomization (nonoperative group, 10; operative group, 2; p = 0.33) differed but remained below the threshold of significance. In the operative group, 18 patients received fracture stabilization with interfragmentary compression screws and 2 received screws and a plate due to comminution. The first surgeon at each operation had at least 5 years of hand surgery experience (level 3)[20].

Primary Outcome

When compared with the contralateral hand at the 1-year follow-up, the mean grip strength was 104% (95% CI, 89% to 120%) in the nonoperatively treated group and 96% (95% CI, 89% to 103%) in the operatively treated group (p = 0.34).

Secondary Clinical Outcomes

For patients who were treated nonoperatively, 19 of 22 (86%; 95% CI, 64% to 96%) had a grip strength of ≥85% of that on the contralateral side, and 17 of 20 (85%; 95% CI, 61% to 96%) who were treated operatively reached this threshold (p = 1) (Table III).

TABLE III Outcome at the Time of Follow-up*

Outcome	Nonoperative (N = 22)	Operative (N = 20)	P Value
Mean grip strength as a percentage of contralateral hand (95% CI)†	104% (89%-120%)	96% (89%-103%)	0.34
Mean grip strength (95% CI)† *(kg)*	35 (29-42)	43 (37-49)	0.07
No. with grip strength ≥85% of contralateral hand† *(no. [%])*	19 (86)	17 (85)	1
No. with rotational deformity‡	1	3	0.33
Mean radiographic shortening at 6 weeks (95% CI) *(mm)*	5.3 (4.2-6.4); 2 missing values	2.3 (0.8-3.9); 5 missing values	0.004
No. with flexion deficit§	0	1	0.48
No. with extension deficit§	1	1	1
Mean TAM (95% CI)# *(%)*	100.2 (96.8-103.6)	99.1 (95.1-103.1)	0.75
Mean overall satisfaction on NRS, 1-10, 1 = best (95% CI)	1.2 (1.0-1.5)	1.7 (1.3-2.0)	0.08
Mean pain under load on NRS, 1-10, 1 = best (95% CI)	1.2 (1.0-1.5)	1.3 (1.0-1.6)	0.68
Mean cosmetic appearance on NRS, 1-10, 1 = best (95% CI)	1.5 (1.1-1.9)	1.7 (1.3-2.2)	0.41
Mean DASH score, 0-100 (95% CI)	1.6 (0.8-2.6)	2.6 (0.9-5.3)	0.89
No. with revision surgery	0	3	
Mean sick leave duration (95% CI) *(days)*	12 (5-21)	35 (20-54)	0.008

*All outcomes other than radiographic shortening were measured at the 1-year follow-up. CI = confidence interval, NRS = numeric rating scale, and DASH = Disabilities of the Arm, Shoulder and Hand score. Continuous data are given as means and 95% CIs. †Grip strength was measured using a Jamar dynamometer. ‡Number of patients exhibiting rotational deformity on clinical examination; p value was calculated using the Fisher exact test. §Number of patients with any degree of deficit in the injured hand. #TAM = total active motion, shown as a percentage relative to the contralateral hand.

In the nonoperatively treated group, radiographic fracture shortening increased from a mean of 4.8 mm (95% CI, 3.8 to 5.7 mm) at inclusion to 5.3 mm (95% CI, 4.2 to 6.4 mm) at the 6-week follow-up. Of those treated operatively, shortening decreased from a mean of 4.8 mm (95% CI, 3.9 to 5.6 mm) to 2.3 mm (95% CI, 0.8 to 3.9 mm) at 6 weeks of follow-up (Table III). Of the 10 patients with initial rotational deformity in the nonoperatively treated group, 1 retained a slight 5° supination deformity without scissoring or functional problems. In the operative group, 2 patients had rotation at inclusion but both showed no rotation at the time of follow-up. Conversely, 3 patients in the operative group had rotation at the time of follow-up (3°, 5°, and 5°) despite having shown no rotation at inclusion. None of those 3 patients experienced scissoring.

The TAM percentage was 100.2% (95% CI, 96.8% to 103.6%) in the nonoperative group and 99.1% (95% CI, 95.1% to 103.1%) in the operative group.

At the 1-year follow-up, the mean DASH score was 1.6 (95% CI, 0.8 to 2.6) in the nonoperative group and 2.6 (95% CI, 0.9 to 5.3) in the operative group (p = 0.89). Patient-reported overall satisfaction was 1.2 (95% CI, 1.0 to 1.5) and the pain score under load was 1.2 (95% CI, 1.0 to 1.5) in the nonoperative group; corresponding scores in the operative group were 1.7 (95% CI, 1.3 to 2.0; p = 0.08) and 1.3 (95% CI, 1.0 to 1.6; p = 0.68). The mean sick leave duration of 12 days (95% CI, 5 to 21 days) in the nonoperative group was significantly shorter than that in the operative group (35 days [95% CI, 20 to 54 days]) (p = 0.008) (Table III). The cosmetic results were rated as 1.5 (95% CI, 1.1 to 1.9) in the nonoperative group and 1.7 (95% CI, 1.3 to 2.2) in the operative group (p = 0.41).

Sensitivity Analysis

A linear regression analysis to investigate grip strength adjusted for hand dominance was performed, and an estimated difference of 22.2% (p = 0.007) in favor of dominant-sided hands was observed.

Costs and Operative Time

The average estimated cost for each treatment was 1,347 U.S. dollars (USD) for nonoperative treatment and 3,834 USD for operative treatment (Table IV). The mean operative time was 63 minutes (range, 35 to 93 minutes).

Complications

In the nonoperative group, only 1 patient had a minor complication: triggering of the fractured finger on rare occasions. Three patients in the operative group underwent revision surgery (2 due to early osteosynthesis failure, and 1 implant removal due to local discomfort at 3 months postoperatively). Three patients in the operative group experienced minor complications (see Supplementary Appendix E).

Discussion

The 1-year outcome after nonoperative treatment of a single spiral and/or oblique displaced finger MSF was comparable

TABLE IV Estimated Treatment Costs per Patient

Unit	Costs per Unit *(USD)*	Treatment			
		Nonoperative		Operative	
		No. of Units	Costs *(USD)*	No. of Units	Costs *(USD)*
Visit to emergency department	457	1	457	1	457
Operating room, per minute*	34	0	0	63	2,142
Material					
Implants	26/screw	0	0	2	52
Orthosis	34	1	34	1	34
Outpatient physiotherapy/occupational therapy	223	2	446	2	446
Outpatient appointment with nurse	223	0	0	1	223
Outpatient appointment with physician	375	1	375	1	375
Radiographs	35	1	35	3	105
Total			1,347		3,834

*The $34 cost per minute was calculated based on the mean time in the operating room (63 minutes) and recorded total operating room costs for the operative procedures (2,142 USD).

with that after operative treatment. The lower limit of the 95% CI around the mean grip strength percentage was above the NIM, confirming the noninferiority of nonoperative treatment. Overall, outcomes were similar in both groups, except for the shortening of the fractured metacarpal and significantly shorter sick leave duration in the nonoperative group.

To our knowledge, no prospective studies have compared nonoperative and operative treatment of finger MSFs[2]. However, an RCT of metacarpal neck fractures compared nonoperative versus operative treatment of the little finger. In that study, 85 patients were randomized to either intramedullary wiring or early mobilization. The authors reported no significant differences between the groups in QuickDASH (a shortened version of the DASH) scores, pain, satisfaction, finger range of motion, grip strength, or quality of life[21].

In a retrospective study, Westbrook et al. compared nonoperative and operative treatment of metacarpal neck fractures and MSFs[22]. At a minimum follow-up of 2 years, no significant differences in DASH scores, grip strength, or self-reported aesthetics were found between the groups. Unfortunately, the follow-up rates were low (17% for nonoperative treatment and 54% for operative treatment)[22]. In our study, the DASH scores were low and not significantly different between the treatment groups, which is consistent with other studies[5]. Nonsignificant differences were likewise found between the good outcome observed in both groups for overall satisfaction (nonoperative group, 1.2; operative group, 1.7) and the cosmetic result (nonoperative group, 1.5; operative group, 1.7). Other studies investigating metacarpal neck fractures have shown patient satisfaction with the cosmetic appearance to be higher, but not significantly so, in the operative group[21,23].

The complication rate in the operative group (15%) may seem high on first inspection. However, because of the prospective study design, even minor complications that could have escaped detection in retrospective studies were noted. Fewer complications might have been expected if the surgery had been performed by more experienced surgeons (level 4 or 5)[20], but the lower experience level in our study reflects local practice in Sweden for this fracture type and is probably comparable with that in many countries.

Sick leave duration was significantly lower in the nonoperative group (12 days) than in the operative group (35 days). Most patients with finger MSFs are of working age, and the economic burden of finger MSFs has been discussed in detail by Taha et al.[3]. In our study, the costs for operative treatment were higher than those for nonoperative treatment, without inclusion of the societal costs of sick leave and the complications that occurred exclusively in the operative group.

Limitations and Strengths

As with other noninferiority studies, the risk of type-II errors is important to consider if there are no significant differences between the groups. In our study, we chose an NIM of a grip strength decrease of 15% based on previous reports of hand strength differences of approximately 10% and an additional 5% to account for the expected margin of lowered strength after injury and treatment[19]. Such an arbitrary threshold could be criticized; however, patients who were treated operatively showed similar grip strength outcomes. While the amount of expected variance between the dominant and nondominant hands also remains a subject of debate[24], our findings indicated a clear bias toward a stronger grip in the dominant hand in our sample. Given the fact that noninferiority was reached despite the nonoperative group containing a majority of nondominant injured hands strengthened the conclusion of noninferiority of nonoperative treatment.

Shortening was analyzed as a secondary outcome although it had not been specified in the pre-study protocol because it has been considered relevant for hand and finger function[11-13]. However, measuring metacarpal shortening is challenging, and the method of using the metacarpal line is vulnerable to the variability of normal anatomy[25]. Making radiographic measurements between fracture edges is less accurate. However, the only way to assess the shortening accurately is with use of bilateral radiographs, which we did not use. The hand grip assessment was not conducted by an individual blinded to treatment group, which was a potential source of detection bias.

Several secondary outcome measures failed to show significant differences between the groups, which may represent underpowering rather than noninferiority. In particular, it was not possible to perform a reliable statistical analysis of the small number of complications.

The strengths of this study were its design and the follow-up of 100% of the participants. RCTs offer the highest level of evidence but are rare in hand surgery. When trials on scaphoid and distal radial fractures are excluded, only 78 RCTs of the hand have been conducted over the past 35 years, of which only 16 compared nonoperative and operative treatment[26]. With the RCT described herein, we hope to further support evidence-based decision-making between nonoperative and operative treatment for finger MSFs.

Conclusions

When treated with unrestricted mobilization, patients with a single spiral and/or oblique finger MSF have similar outcomes when compared with patients who were treated operatively, despite metacarpal shortening. Nonoperative treatment generates shorter sick leave duration and substantially lower costs. We conclude that nonoperative treatment with immediate mobilization should be advocated in patients with a single MSF of the type investigated in this study.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/H304). ■

NOTE: The authors thank research nurses Eva Nordin and Margareta Sundqvist for their help organizing follow-up visits as well as the hand therapy staff at Uppsala Akademiska Hospital and Falu Lasarett for help evaluating range of motion and grip strength. We also thank all other staff at both centers who assisted in the management of the study patients.

Fredrik Peyronson, MD[1]
Cecilia Stalberg Ostwald, MD[1,2,3]
Nils P. Hailer, MD[1]
Grey Giddins, FRCS(Orth)[4]
Torbjörn Vedung, MD, PhD[1,5]
Daniel Muder, MD, PhD[1,2]

[1]Department of Surgical Sciences/Orthopedics & Hand Surgery, Uppsala University Hospital, Uppsala, Sweden

[2]Department of Orthopedics, Falun Hospital, Falun, Sweden

[3]Center for Clinical Research Dalarna, Uppsala University, Falun, Sweden

[4]The Hand to Elbow Clinic, Bath, United Kingdom

[5]Elisabeth Hospital, Aleris Healthcare AB, Uppsala, Sweden

Email for corresponding author: danielmuder@email.com

References

1. van Onselen EBH, Karim RB, Hage JJ, Ritt MJPF. Prevalence and distribution of hand fractures. Journal of Hand Surgery. 2003 Oct;28(5):491-5.

2. Taha RHM, Grindlay D, Deshmukh S, Montgomery A, Davis TRC, Karantana A. A Systematic Review of Treatment Interventions for Metacarpal Shaft Fractures in Adults. Hand (N Y). 2022 Sep;17(5):869-78.

3. Taha R, Leighton P, Bainbridge C, Montgomery A, Davis T, Karantana A. Protocol for surgical and non-surgical treatment for metacarpal shaft fractures in adults: an observational feasibility study. BMJ Open. 2021 Jun 29;11(6):e046913.

4. Al-Qattan MM. The use of a combination of cerclage and unicortical interosseous loop dental wires for long oblique/spiral metacarpal shaft fractures. J Hand Surg Eur Vol. 2008 Dec;33(6):728-31.

5. Khan A, Giddins G. The outcome of conservative treatment of spiral metacarpal fractures and the role of the deep transverse metacarpal ligaments in stabilizing these injuries. J Hand Surg Eur Vol. 2015 Jan;40(1):59-62.

6. Burkhalter WE, Reyes FA. Closed treatment of fractures of the hand. Bull Hosp Jt Dis Orthop Inst. 1984 Fall;44(2):145-62.

7. Workman CE. Metacarpal fractures. Mo Med. 1964 Aug;61:687-90.

8. Al-Qattan MM. Outcome of conservative management of spiral/long oblique fractures of the metacarpal shaft of the fingers using a palmar wrist splint and immediate mobilisation of the fingers. J Hand Surg Eur Vol. 2008 Dec;33(6):723-7.

9. Retrouvey H, Morzycki A, Wang AMQ, Binhammer P; Canadian Plastic Surgery Research Collaborative. Are We Over Treating Hand Fractures? Current Practice of Single Metacarpal Fractures. Plast Surg (Oakv). 2018 Aug;26(3):148-53.

10. Svenska Frakturregistret. This shows the data in the Fracture Register. Accessed 2022 Oct 24. https://sfr.registercentrum.se/.

11. Low CK, Wong HC, Low YP, Wong HP. A cadaver study of the effects of dorsal angulation and shortening of the metacarpal shaft on the extension and flexion force ratios of the index and little fingers. Journal of Hand Surgery. 1995 Oct;20(5):609-13.

12. Meunier MJ, Hentzen E, Ryan M, Shin AY, Lieber RL. Predicted effects of metacarpal shortening on interosseous muscle function. The Journal of Hand Surgery. 2004 Jul;29(4):689-93.

13. Strauch RJ, Rosenwasser MP, Lunt JG. Metacarpal shaft fractures: the effect of shortening on the extensor tendon mechanism. The Journal of Hand Surgery. 1998 May;23(3):519-23.

14. Kollitz KM, Hammert WC, Vedder NB, Huang JI. Metacarpal fractures: treatment and complications. Hand (N Y). 2014 Mar;9(1):16-23.

15. Vasilakis V, Sinnott CJ, Hamade M, Hamade H, Pinsky BA. Extra-articular Metacarpal Fractures: Closed Reduction and Percutaneous Pinning Versus Open Reduction and Internal Fixation. Plastic and Reconstructive Surgery - Global Open. 2019 May 21;7(5):e2261.

16. Trampisch US, Franke J, Jedamzik N, Hinrichs T, Platen P. Optimal Jamar dynamometer handle position to assess maximal isometric hand grip strength in epidemiological studies. The Journal of Hand Surgery. 2012 Nov;37(11):2368-73.

17. Atroshi I, Gummesson C, Andersson B, Dahlgren E, Johansson A. The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: reliability and validity of the Swedish version evaluated in 176 patients. Acta Orthopaedica Scandinavica. 2000 Dec;71(6):613-8.

18. Hjermstad MJ, Fayers PM, Haugen DF, Caraceni A, Hanks GW, Loge JH, Fainsinger R, Aass N, Kaasa S; European Palliative Care Research Collaborative (EPCRC). Studies comparing Numerical Rating Scales, Verbal Rating Scales, and Visual Analogue Scales for assessment of pain intensity in adults: a systematic literature review. Journal of Pain and Symptom Management. 2011 Jun;41(6):1073-93.

19. Wang YC, Bohannon RW, Li X, Sindhu B, Kapellusch J. Hand-Grip Strength: Normative Reference Values and Equations for Individuals 18 to 85 Years of Age Residing in the United States. J Orthop Sports Phys Ther. 2018 Sep;48(9):685-93.

20. Tang JB, Giddins G. Why and how to report surgeons' levels of expertise. J Hand Surg Eur Vol. 2016 May;41(4):365-6.

21. Sletten IN, Hellund JC, Olsen B, Clementsen S, Kvernmo HD, Nordsletten L. Conservative treatment has comparable outcome with bouquet pinning of little finger metacarpal neck fractures: a multicentre randomized controlled study of 85 patients. J Hand Surg Eur Vol. 2015 Jan;40(1):76-83.

22. Westbrook AP, Davis TRC, Armstrong D, Burke FD. The clinical significance of malunion of fractures of the neck and shaft of the little finger metacarpal. J Hand Surg Eur Vol. 2008 Dec;33(6):732-9.

23. Strub B, Schindele S, Sonderegger J, Sproedt J, von Campe A, Gruenert JG. Intramedullary splinting or conservative treatment for displaced fractures of the little finger metacarpal neck? A prospective study. J Hand Surg Eur Vol. 2010 Nov;35(9):725-9.

24. Armstrong CA, Oldham JA. A comparison of dominant and non-dominant hand strengths. Journal of Hand Surgery. 1999 Aug;24(4):421-5.

25. Sletten IN, Nordsletten L, Hjorthaug GA, Hellund JC, Holme I, Kvernmo HD. Assessment of volar angulation and shortening in 5th metacarpal neck fractures: an inter- and intra-observer validity and reliability study. J Hand Surg Eur Vol. 2013 Jul;38(6):658-66.

26. Mousoulis C, Thomas K, Leighton P, Deshmukh S, Grindlay D, Karantana A. Treatment interventions for hand fractures and joint injuries: a scoping review of randomized controlled trials. J Hand Surg Eur Vol. 2020 Feb;45(2):111-8.

Update

This article was updated on January 18, 2023, because of a previous error, which was discovered after the preliminary version of the article was posted online. On page 103, in the first column of Table III, the continuous outcomes, which had been given as “Median” and “(range)”, are now given as “Mean” and “(95% CI)”, respectively.